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Group No.8

How Small Satellites Can Comply with the Space Debris Mitigation Guidelines?

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Background (1)

The **Inter-Agency Space Debris Coordination Committee (IADC)** is an international forum of governmental bodies for the coordination of activities related to space debris issues.

One of its efforts is to recommend space debris mitigation guidelines, which can be considered during planning and design of spacecraft and launch vehicles in order to minimize or eliminate generation of debris during operations.

The guidelines provide **existing practices** that have been identified and evaluated for **limiting the generation of space debris** in the environment.

Background (2)

The **Scientific and Technical Subcommittee (STSC)** of the **United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS)** developed a set of recommended guidelines based on the technical content and the basic definitions of the IADC space debris mitigation guidelines.

This group discussion focuses on Guideline 3 and Guideline 6.

- ✓ **Guideline 3 limits the probability of accidental collision in orbit.** Therefore, the probability of accidental collision with known objects during the system's launch phase and orbital lifetime should be estimated and limited.
- ✓ **Guideline 6 limits the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission.** Therefore, spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the LEO region should be removed from orbit in a controlled fashion.

Scope of Group Discussion

The scope of group discussion includes but is not limited to

- ✓ A better understanding of the current space debris environment,
- ✓ Ideas how to comply with the guidelines, and
- ✓ Ideas how to minimize impact of small satellites insertion on the future space debris environment

Background and Motivation

- Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee

- Space Debris Mitigation Guidelines of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space
  - ✓ Guideline 3 limits the probability of accidental collision in orbit
  - ✓ Guideline 6 limits the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit region after the end of their mission

- The scope of group discussion includes but is not limited to
  - ✓ A better understanding of the current space debris environment,
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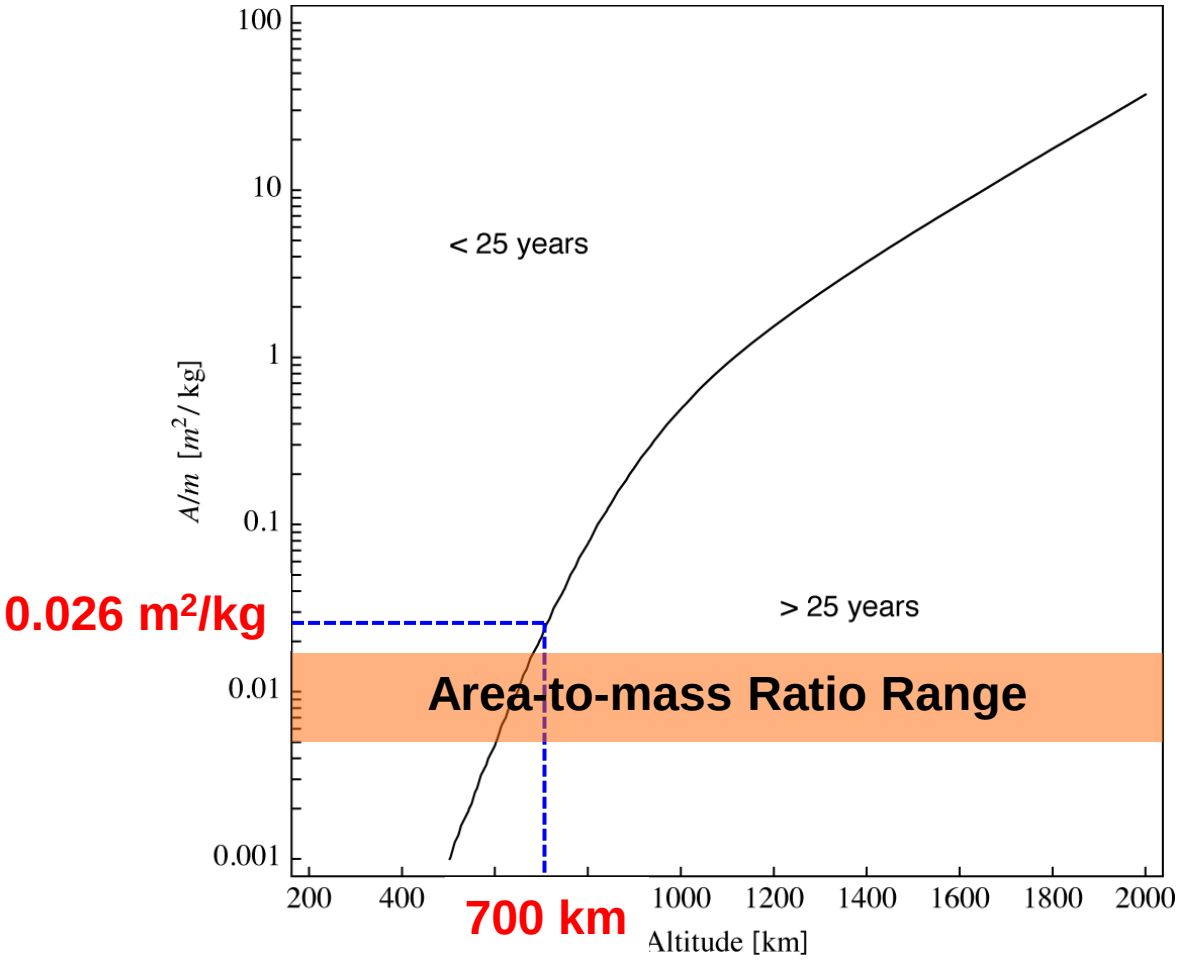
Satellite Classification and Area-to-mass Ratio Range

Class (cm)	Mass (kg)	Area-to-mass ratio (m^2/kg)
10	0.9 – 3.0	0.005 – 0.017
20	TBD	TBD
30 – 50	< 50*	> 0.007

* w/ satellite frame

Criterion for the 25-year Rule



Options Applicable for Small Satellites @ 700 km Alt.

In order to have an area-to-mass ratio > 0.026 m^2/kg

1. Limit their **mass**: **< 14.4 kg** for a cube **50 cm** on a side (Note: **satellite frame ~ 1.1 kg**)
2. Enlarge their **average cross-sectional a**rea at the beginning or the end of their mission: **> 1.3 m^2** for a mass of 50 kg (Note: **average cross-sectional area of a cube 50 cm on a side ~ 0.4 m^2**)

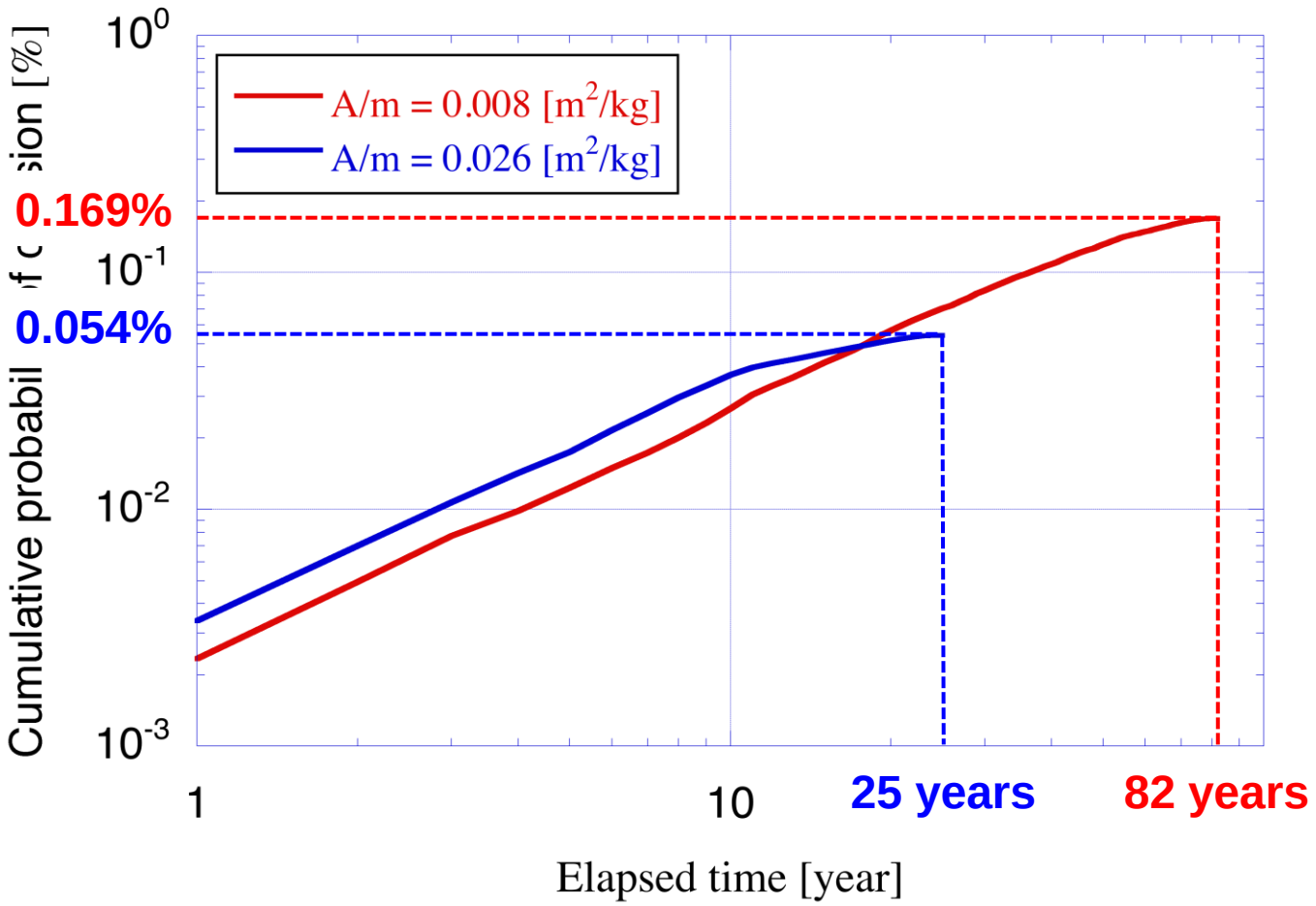
Therefore,

- ✓ Option 1 seems to be **nearly impossible**
- ✓ Option 2 seems to be **quite possible but may conflict with Guideline 3**

Assumptions to Discuss Guideline 3 for Small Satellites

- LEODEEM, an orbital debris evolutionary model for the low-Earth orbit region, used for this study
  - ✓ Initial population includes all > 10 cm objects with perigee altitudes < 2000 km on 1 Jan. 2009
  - ✓ Orbital insertion history for the years 2001 through 2008 for > 10 cm objects with perigee altitudes < 2000 km repeated as the 8-year traffic cycle
- Sun-synchronous orbit at **700 km** alt. with an inclination of 98.2 deg.
- A small satellite with a mass of **50 kg** in a cube **50 cm** on a side
  - ✓ Average cross-sectional area **~ 0.4 m^2**
  - ✓ Area-to-mass ratio **~ 0.008 m^2/kg**

Cumulative Probability of Accidental Collision



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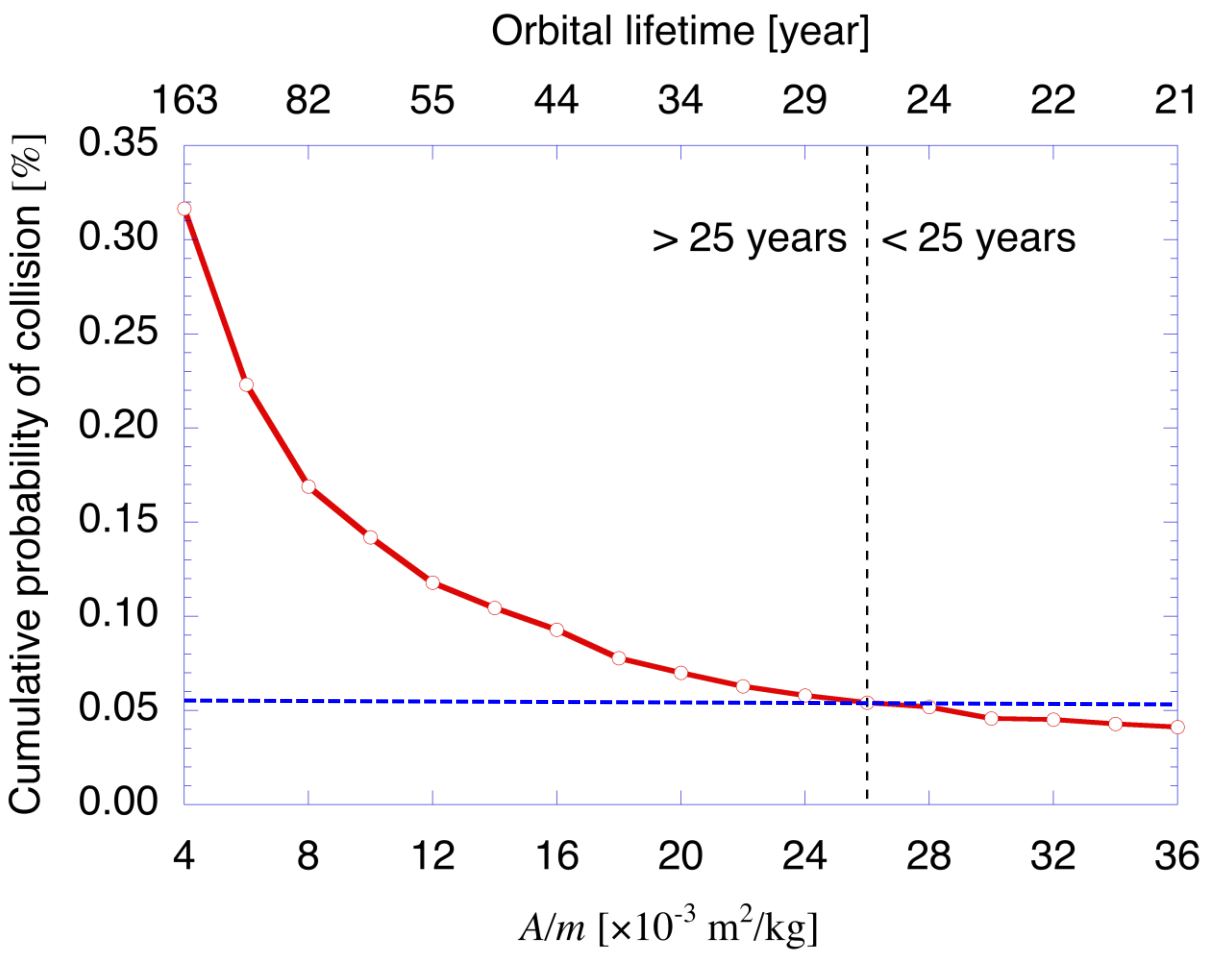
Cumulative Probability of Accidental Collision



Concluding Remarks

- This paper concerns about how small satellites can comply with **Guideline 6** or **the 25-year rule**
- This paper compares **two options applicable for small satellites** to limit their orbital lifetime within 25 years
- **Enlargement of their average cross-sectional area may be a quite promising option**
- This paper also concerns that **the promising option may conflict with Guideline 3**
- This paper clearly demonstrates:
  - ✓ **the promising option raises the probability of accidental collision**, but
  - ✓ **the 25-year rule can reasonably and adequately reduce the cumulative probability of accidental collision at the re-entry**